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The Art of Picopoly

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Abstract

The various forms of handouts in university studies cover a large spectrum from complete reference texts to cheat-sheets. We present our experiences in very compact handouts, "pico" handouts, that we call "picopoly" in French. We have been using them consistently in various learning formats, from full semester modules to conferences, and in very different domains, from epistemology to algorithmics. The initial aim was to clarify for the students the expected inputs, i.e. prerequisites and context knowledge, and outputs, i.e. learning outcomes. Very compact, they only give an overview of these inputs and outputs, but they are intended as maps of territories that will be explored during the learning experience.

1 Introduction

The forms of handouts in university studies go from complete reference texts to cheat-sheets, including exercise sheets, practical work instructions, or printed copies of slideshows, etc. Each form assumes a different role for the handout, but our experience is that very often the form is not really chosen on purpose but simply out of local traditions and personal feelings. For instance, an institution or a student association may assume that a copy of a slideshow is a mandatory part of the handout package. Note that even assuming that a slideshow exists is another *cliché* since the actual relevance of a slideshow is highly dependent on domains and personal approaches. Among personal feelings is the fear that too complete handouts will favor absenteeism. This often leads to handout strategies where copies of slideshows are distributed after the corresponding lecture. We believe that nobody should be incriminated in particular, because all parties, the teachers, the students, and the institutions, are equally driven by parasitic feelings. Students want to be reassured by a lot of documentation, teachers want to be reassured that students are not dissatisfied, and the institutions are happy that everybody is happy. Several articles describe these ambiguities and conflicting views on handouts [8, 5]. Some even conclude that there is no evidence that the mode of distribution of handouts, and even their very existence, has a measurable effect [9, 4]. They often describe these phenomena from the point of view of one teaching discipline or one teaching level, but we believe these observations can be generalized to most disciplines and levels.

Altogether, we consider that even if the only effect of handouts is to make everybody happy, it is a useful effect. However, what we want to do is to go further than using handouts as a reassuring balm, but rather to use them in a global strategy.

The day-to-day teaching experience shows that this tradition-laden approach to university teaching causes severe anomalies. We focus on two of them, namely the lack of agreement on prerequisites and context knowledge, and the lack of agreement on learning outcomes. This leads to contentious situations in which all the unsaid assumptions make surface.

The lack of agreement on prerequisites and context knowledge leads to situations where teachers complain that the education level is decreasing (eg. measured by results of teaching interactions or by the results of homeworks), or students complain that the course is too difficult, too abstract, too ... The standard institutional answer to this is to make explicit the dependencies between courses, e.g. CS101 is a prerequisite to CS205. However, this does not work very well because it ignores the fact that most students pass final exams with gaps in their acquisitions, and that all the outcomes of the first course are not used as prerequisites to the second course. This also ignores the fact that mobility students may have studied a different first course, or even a really different cursus that has been validated as a whole as roughly equivalent to the CS1 cursus. This shows that the institutional communication on course dependencies is not precise enough. However, we believe that institutions do their part fine. It is not the institutions that should make there documentation more precise, because it would not be the proper level of detail for their purpose. It is the course teacher in her[1] own documentation who should be more explicit.

The lack of agreement on the learning outcomes leads to situations where teachers complain that the education level is decreasing (eg. measured as the results of the final exam), or students complain that the exams was unfair. A crude manifestation of this is when a fellow teacher is worried by her next exam subject, and suddenly is very happy to have found a bright idea, a "very interesting" subject. It is in fact "Chronicle of a Death Foretold" [7]! An exam should not be "interesting" to the teacher, but it must be fair with the students. To be fair is to be faithful with some explicit contract.

Our answer to these two anomalies is to develop a compact format of handouts that presents on one side the prerequisites, and on the other side an overview of the outcomes. We have called this format a "picopoly" from the SI[2] prefix "pico" (itself derived from Italian "piccolo", small, and Spanish "pico", sharp), and the French diminutive for "polycopié", a handout. We then build a global strategy in which the picopoly is used during teaching, including preparation of evaluation.

[1] Her stands for her/his, and similarly she stands for she/he.

[2] International system of units - Système international d'unités ; ISO 80000-1:2009

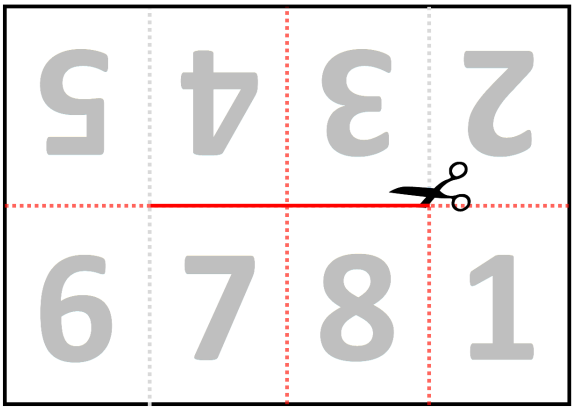

Figure 1: A picopoly as a flat sheet

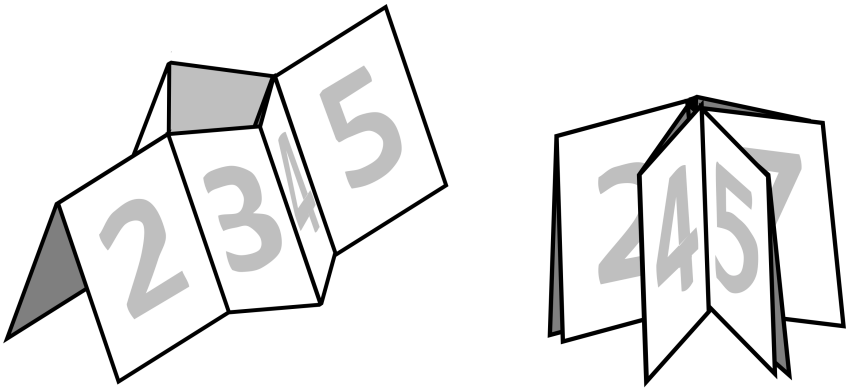

Figure 2: Folding a picopoly

2 The structure of a picopoly

2.1 The folding

The structure of a picopoly is made of a single sheet of paper folded as shown in Figure 1 and 2.

Figure 1 shows the structure of a picopoly before folding it. Fold lines (mountain folds as red dotted lines, and valley folds as grey dotted lines) mark the borders of 8 pages. The numbers in the figure show the pagination and the orientation of pages. The solid red segment marks a slot that must be opened in the paper sheet.

Figure 2 shows the folding itself. Again, numbers represent pages. This folding belongs to folklore, sometimes called "hotdog" booklet, and it is used as

a routine in many primary schools to initiate children to the joy of in-folio composition. It is also often called "origami" booklet, though it would be preferable to call it "kirigami" booklet, because of the cut in the paper.

It is readily apparent that once folded a face of the paper sheet is hidden. We call it the verso side. The visible face is the recto side. In usual instances of the hotdog booklet folding, the verso side is simply wasted. Instead of a flaw we make of this accessibility difference a feature. The verso face is used to present the prerequisites or context knowledge, and the recto face is used for the learning outcomes. The inputs become what is readily accessible before folding, and the output is what is accessible after folding. Thus, folding is kind of a metaphor for preparing the course.

Next two sections explain how we have chosen to inhabit the physical constraints of the hotdog booklet format. It constitutes our design rules for picopolies.

2.2 The recto side — 8 pages

The recto face is paginated, and we chose to use that as a strict guide to redaction. Page 1 is the front page, with a title, authorship, and introduction/motivations. Page 8 is the back page, with a conclusion and bibliography. Remains 6 pages for an overview of the subject. This is the first of the main two difficulties in composing a picopoly. Indeed, we prefer to align the structure of the overview on the 6 pages, which leads to 6 sub-subjects, which might not be so natural at first sight. So a large part of the reflection required to prepare a picopoly is how to align the subject on 6 equally-sized pages. This can be relaxed by accepting that two facing pages treat a same subject, or that one page treats 2 small sub-subjects.

Picopolies are printed in A3[3], 29.7 cm $\times$ 42.0 cm. Texts are composed in 8 pt, using a sans-serif police. That sounds small but experience shows it can be read comfortably, especially because pages are small. Pages are 14.8 cm high and 10.5 cm wide (equivalent to A6: A3 area divided by 8). Left, right and top margins are about 0.5 cm. Bottom margin is 1.0 cm to allow for page numbers.

Since folding lines are marked on the paginated face, it is important that they fall in their exact due position. However, their is a technical difficulty with many printers. They add a margin, called technical margin, and they reduce the document to fit in what remains of the physical size of the sheet of paper minus the technical margin. This process slightly changes the proportions of the printed document. The mid-width fold and the mid-length fold will be correct if the technical margin is the same along each border. However, the quarter-length folds (e.g. between pages 6 and 7) will be off-position. A solution is to anticipate the technical margin, but it is a never-ending story because technical margins depend too much on the printer. Another solution is to find a printer that do not add any technical margin, or a printer pilot that format the document to the physical dimensions of the paper sheet. In the latter case, a technical margin

[3]ISO 216

may still exist, but it is taken from the document instead of being taken from the sheet of paper. It is the solution we have chosen, calibrating the picopoly margins so that it corresponds to the technical margin.

As a basis, we decided that texts can be highlighted in one of two colors:

- a faded blue, mainly for definitions and highlighted terms;
- a faded red, mainly for examples, and opposition with other highlighted terms (e.g. **this** and not **that**).

More colors could be used, but we try to limit to two. All highlighted text is composed in bold to compensate for the faded shades of colors, and for accessibility to colour-blind people.

Underlining or boldface are never used as such in paragraphs. Page titles are composed in 10 pt bold.

Most of our experience with picopolies is for courses in computer science curriculae. As is usual in this discipline, we also use `courier` police for program-like texts (texts that are meant to be presented as it to a computer system), and *italics* for specification texts.

Page limits are marked grey or red, according to how they should be folded: red for mountain folds, and grey for valley folds. At the point where pages 1, 2, 3 and 8 meet, a red dot is printed, as well as at the point where pages 4, 5, 6 and 7 meet. They delimit the slot that must be cut between pages 8-7 and 3-4.

2.3 The verso side — a mosaic of text items

On the opposite, the verso page is not paginated, and we chose to compose it as a mosaic of small items (tiles). We think it is in accordance with the role of this page which addresses a reader whom we do not know precisely the actual background. Composing this page is the second difficulty. It forces to lay down what are the precise prerequisites or useful context knowledge. Tiles from different themes are filled in with different colors. Tiles from a given theme have the same color, and they are numbered to help finding one's way in the mosaic. Reading and folding instructions are written on top of the page, including the key for background colors.

Tile texts are composed using the same rules as page texts, except for the dimensions of the tiles. In effect, tiles are often rectangular, in a landscape orientation, but not always. Some tiles are even not rectangular. Some tiles are large, other very small. They are not meant to be read in a strict order, but they are partially numbered to help the reader who wants to read the whole text. A secondary difficulty is to design the tiles so that they pave the page as exactly as possible. A difficulty in the difficulty is to try to ensure that the slot cut in the page does not go through text.

3 Usage

3.1 The student

The role attributed to the reader is twice. First, she must read the verso page, the prerequisites or context knowledge, before folding, and acknowledge whether she already knows the recalled notions. If she acknowledges she does, all is right, but the reader is warned that these notions are important to start the course. She is also warned of the actual notations/definitions that will be in use during the course. If the reader acknowledges she does not know/remember a notion, she is invited to search by herself some help to acquire the notion. The help could be a book, a tutorial, a video, a friend, etc. To give the substance of all prerequisites is not the goal of the verso page. It is only a kind of autotest.

After folding the picopoly, the second role of the reader is to browse the course overview. She must read it as a tourist reads a map, or as an aviator contemplates a bird view of a territory. It is normal to not understand everything at first sight, but as the course progresses the reader should understand more and more. So, the overview part is also a kind of autotest. The contract is that though not everything is given in full details in the overview, it must be faithful to the actual content of the course.

3.2 The teacher

As for the teacher side, picopolies are not meant to replace all other handouts. They are more like a vademecum to accompany the other documents. We use them alongside copies of slideshows, exercise sheets, instructions for practical works, etc. However, while all other handouts are sequence, or even event, oriented, the picopoly gives the broad picture of the entire course. To be consistent with this role we use it at a reference frame to mark the progress of the course or the important use of some prerequisite. Hence, we use the picopoly as a map: "here we are", "now, we are entering this area", etc. Note that in our usage, the picopolies are the only paper printed handouts; all other documents are available in electronic form right from the beginning of the course.

There is a debate on whether distributing handouts arms note-taking and memorization abilities. The debate may focus on the very existence of handouts, their completeness, or the moment they are distributed (before or after the lectures). We believe that if note-taking and memorization are considered a desired ability (as we do), the best is to incorporate them in the teaching and evaluation process. We refuse to consider that such operational ability is a prerequisite, because it would be avoiding the issue and charging our predecessor level colleagues of all responsibilities. As a general rule, we believe it is never too late to acquire these kinds of operational abilities, including spelling and argumentation.

So, we first explain the articulation between handouts, lectures, and note-taking, and between all documents and a memory aid or cheat-sheet. In particular, we explain that the picopoly is definitely not a good memory aid because

of its bird view position. The global picture should be remembered by the students, but we agree that some technical details may need a memory aid. We do not like the cheat part of cheat-sheet as it seems to imply an immoral stance, but we insist on the aid part of memory aid as it implies an auxiliary role to an existing memory. Second, we organize exams on the closed-book mode with personal hand-written memory aids allowed. A study [2] shows it is an effective compromise between closed- and open-book modes.

We do not evaluate the memory aids per se, because we think it is a very personal affair with the student and herself, but being in a continuous assessment framework, we comment after each control on the memory aids we have seen. For instance, we observe that first memory aids are often dense unstructured texts. After having commented on the possibility to use more visual tools like tables, diagrams, mind-maps, etc., we observe that the students adopt progressively a mixed approach, sometimes very creative, that combines different tools for what they are the most useful to. In doing so, we believe we helped students in developing their note-taking and memorizing ability.

Very often, students observe themselves that they did not need use their memory aid during the exam. It is the paradox of hand-writing a memory aid. The very effort and concentration needed for writing it helps in memorizing [1, 6]. Some authors even show that it stimulates specific brain activities [3].

Though the initial motivation for picopolies was to clarify the prerequisites and outcomes of an entire course, we departed slightly from this initial role by designing picopolies for parts of courses, or even picopolies for specific prerequisites. In the later case, the verso will be devoted to context knowledge, and the recto will present the great lines of the prerequisites. We also often distribute to mobility students the picopolies of the courses they did not follow but are prerequisites to courses that they will follow.

We noticed an interest about the picopoly format from the students. This cannot come from the content since it is plain academic content in a rather terse form! We believe it comes from the form itself that intrigues the reader. We also noticed that many students are puzzled by the folding. In fact, we believe it transgresses a tacit line that separates intellectual skills from manual skills. It is something we already observed when instructing students to design tangible models (e.g. made of building blocks, or of cans and straws) of abstract concepts (e.g. a file system, or a Turing machine). We think this transgression is a positive by-product. Finally, we observed that most students used to picopolies expect the next course will also handout picopolies. Some students with the sense of collection even bind together the whole set of picopolies.

4 Two examples

We present two examples of picopolies. Their two sides are included as illustration only to give a concrete perception of their organization. They are not

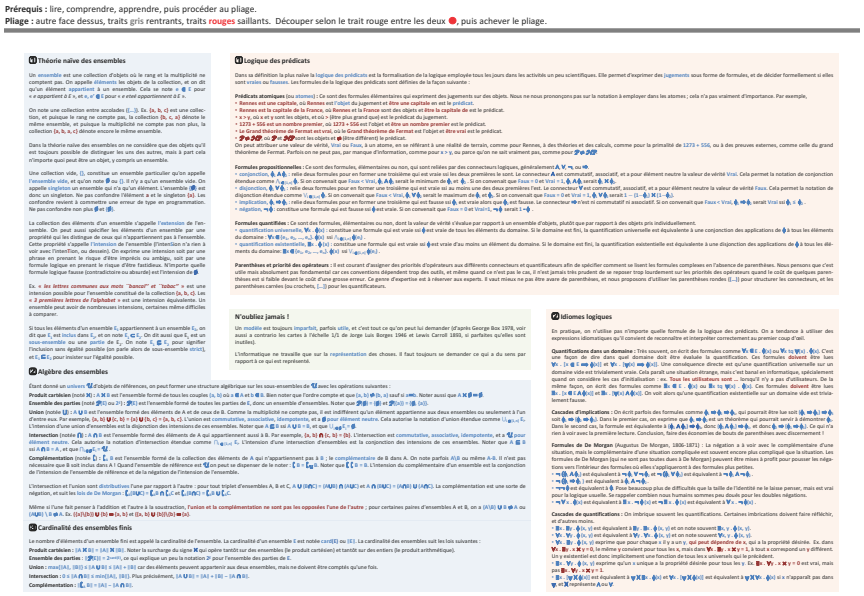

Figure 3: On databases: verso

meant to be read for understanding this article[4].

The first picopoly is representative of the initial motivation, to clarify prerequisites and outcomes. It is related to a course on relational databases, introductory level, where the prerequisites are formal logic and set theory, and the outcomes are relational algebra, SQL, modelling and normalization, and a few system-level aspects like the so-called ACID properties. The prerequisite side (see Figure 3) is composed as a mosaic, with logic related tiles with a beige filling, and set theory tiles filled in light blue. The overview side (see Figure 4) is paginated as follows:

1. Title and motivation: databases are everywhere, they are used for many purposes by many different role-persons, the relational paradigm is the classical one;

2. Historical context: first presented in 1970, the relational paradigm took about 20 years to be fully developed, it is now challenged by new paradigms related to new web-oriented application styles;

3. Relational algebra: based on basic set theory and formal logic, it is the formal model of relational databases;

[4]It is not our objective, and three material reasons oppose to readability: (1) their subject is plain computer science, (2) they are written in French, and (3) they are reduced by a linear factor 5 (i.e. area reduction by 25) to fit in the page as figures.

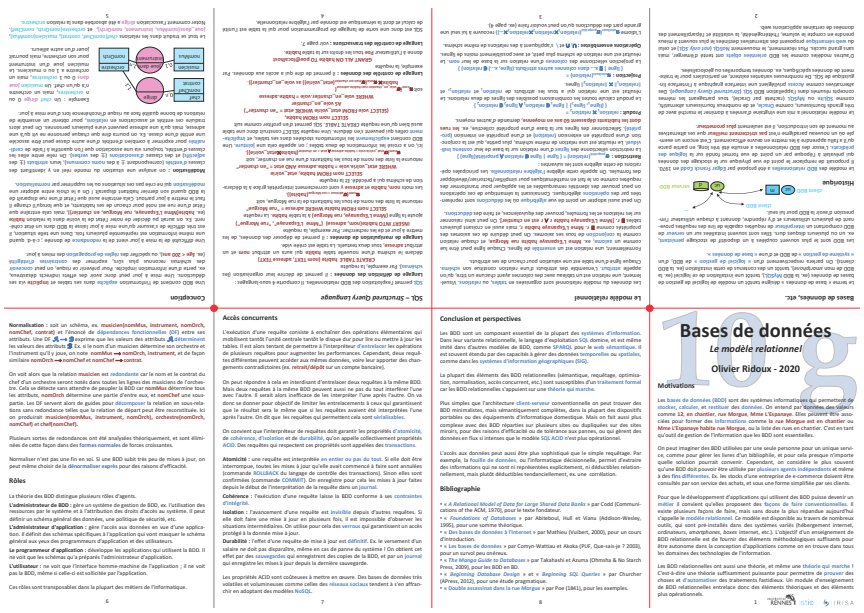

Figure 4: On databases: recto (oriented as in Figure 1; page 1 bottom right, and other pages counter-clockwise)

4. The SQL query language: the concrete programming language that allows to configure, populate, and query databases;

5. Database design and entity-association diagrams: even with the same content, all database organizations are not equally good, there is formal reasons for that, and methods for avoiding bad organizations;

6. Database normalization: ...and methods for repairing bad organizations also exist;

7. Concurrent accesses and ACID properties: many databases are vastly multi-users, very often users are concurrent (e.g. an hotel reservation system), this must be tackled for;

8. Conclusion and bibliography.

This picopoly is handed out at the beginning of the course on databases, and at the beginning of other courses to mobility students who did not follow the database course, but should be in sync with their comrades.

The second example is representative of variations on the theme. It is about agile methods for software development. It is used as a vademecum in a course where agility is the recommended approach for the practical works but about half the students are mobility students. The prerequisite mosaic (see Figure 5)

evolves into a context mosaic, on software development cycles (filled in green), software development risk analysis (filled in red), and on software maturity (filled in blue). The overview side (see Figure 6) is paginated as follows:

1. Title and motivation: developing software is difficult, exposed to many risks, agility is a way for coping for these risks;

2. Historical context: first variants of agility date from the 90's, an Agile Manifesto reconciled different approaches at the beginning of 2000, a few approaches became de facto standard;

3. The Agile Manifesto: exposes values and principles that govern agile methods;

4 and 5. Concepts from SCRUM: one of the de facto standard approaches (an example of a large subject treated on 2 facing pages);

6. Concepts from Extreme programming: one of the pioneer approaches, remains as traces in modern approaches; Agility and time management: how agility helps managing time, especially as one comes close to deadlines (an example of 2 small subjects treated on the same page);

7. Agility and practical works: how to be agile in student works;

8. Conclusion and bibliography.

Other subjects that have been treated as picopolies are:

- algorithmic (primarily as a companion to a full course in an engineering school program, secondarily as a prerequisite for many other courses), used[5] for about 8 years and 100 students per year;
- Turing machine (companion to a short course from a continuous education program for secondary school teachers, and prerequisite to many others), first edition in 2019 and 100 students per year;
- λ-calculus (companion to a short course from a continuous education program for secondary school teachers, and prerequisite to many others), first edition in 2020 and about 100 students per year;
- formal language theory (full course in an engineering school program and prerequisite in others), used for about 10 years and 50 students per year;
- compilation (full course in an engineering school program and prerequisite in others), used for about 10 years and 50 students per year;
- green IT (full course in an engineering school program and a bachelor-level program), used for about 10 years and more than 200 students per year;

[5] including a yearly revision

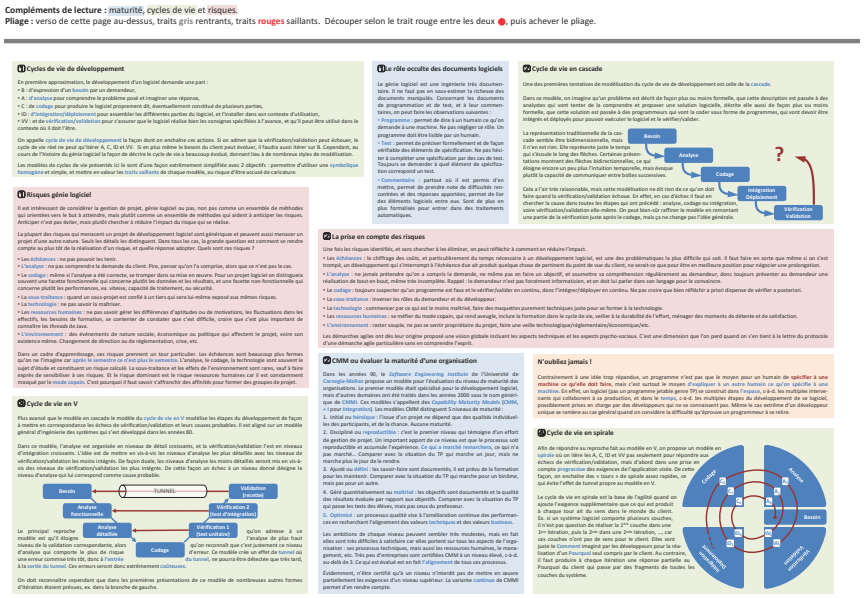

Figure 5: On agile software development: verso

Figure 6: On agile software development: recto (oriented as in Figure 1; page 1 bottom right, and other pages counter-clockwise)

- history of innovation theories (full course from an innovation program in an engineering school and context information in an epistemology program), used for about 6 years and about 30 students per year;
- revolution and disruption in science and innovation (full curse from an innovation program in an engineering school and context information in an epistemology program), used for about 6 years and about 30 students per year;
- the art of the demo (prerequisite and context information in an engineering school program and others), used for about 5 years and about 20 students per year;
- principles of computer systems (full course in a computer science bachelor program), first edition in 2021 and about 250 students per year;
- the curriculum of our Computer Science 2nd year.

Note that the "Turing machine" picopoly contains in itself a tangible Turing machine. So, not only the picopoly format allows to carry in one's pocket all the courses of a semester, but it allows to take with them a universal calculator!

5 Conclusion

We presented a compact format of handouts, which we call picopoly, as a way to clarify prerequisites and learning outcomes of university courses. This role progressively evolved into summarizing prerequisites or summarizing outcomes.

We started developing this approach in 2010, and published 10 picopolies that are used either in courses they were designed for, or in courses where they happen to be useful as a compact reference, including in courses where the teacher is not the author of the picopoly.

Though we made picopolies the cornerstone of our handout strategy, we do not advocate generalizing all the details to every situations. What we advocate is that the picopoly format is an adequate support for making prerequisites and learning outcomes explicit, and that the constraints it imposes on redaction are interesting for themselves. We observes that picopolies are welcomed by students, and that it actually helps to clarify didactic situations. Maybe their unusual form is enough to create a surprise effect that captures the interest of the students and helps them remember what they should remember.

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